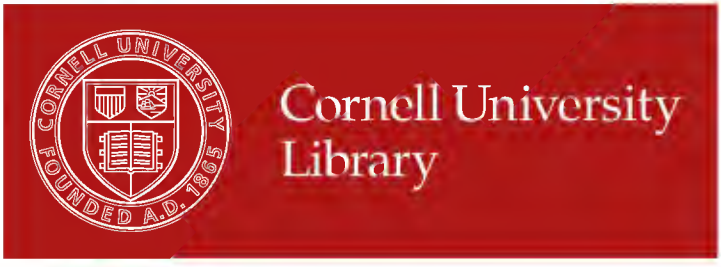

THE

EDUCATION

OF

CIVIL AND MECHANICAL ENGINEERS.

BY

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The MSS. of this paper having been submitted to several gentlemen in England who are interested practically in the education of Engineers, they expressed a strong wish that it should be published.

INTRODUCTION.

THE following paper was written, at the suggestion of friends in England, in the hope that the Council of the Institution of Civil Engineers might be induced to allow it to be read at a meeting of the Institution, and so give an opportunity for the subject of the education of Engineers to be discussed by the Members of the Institution. I have been disappointed in that hope, as the following letter will show :—

"THE INSTITUTION OF CIVIL ENGINEERS,
"Established 1818. Incorporated by Royal Charter 1828.
"25, Great George Street, Westminster, S.W.,
"*25th March*, 1879.

"H. M. Matheson, Esq.,
"3, Lombard Street, E.C.

"Dear Sir,

"I am directed by the Council of the Institution of "Civil Engineers to tender their best thanks for the sub- "mission to them of the original communication by Mr. "Henry Dyer, of Japan, 'On the Education of Civil and "'Mechanical Engineers.' This paper is not, in the judg- "ment of the Council, one that can be regarded as suitable "for reading and discussion at an ordinary meeting of the "members. The Institution, as an Institution, is not an "educational body, nor has it any power to grant what are "ordinarily understood as degrees. Neither has it authority "to interfere with, or regulate the practice of the profession. "The qualifications for admission into the several ranks of "this Institution are settled by the bye-laws, and the "Council feel that they would not be warranted under "existing circumstances in extending their action beyond "the provisions of the Royal Charter of Incorporation and "the bye-laws founded thereon.

"I return Mr. Dyer's manuscript by this post as a book-
"packet, and will ask you to assure him that the Council
"fully appreciate his labours, and regret that they cannot
"take advantage of them on this occasion.

"I remain, dear sir,

"Yours faithfully,

"JAMES FORREST,

"*Secretary.*"

At this distance from London I do not consider it advisable that I should attempt to discuss with the Council the wisdom of their resolution. I would remark, however, that I did not suppose that the Institution was an educational body. I only wished the members to re-consider the conditions of admission to the Institution. The Charter gives full power to do this, as will be seen from the following extract:—"And our will and pleasure is,
"and we further grant and declare, that there shall be a
"general meeting of the members of the said body, politic
"and corporate, to be held from time to time, as herein-
"after mentioned, and that there shall always be a Council
"to direct and manage the concerns of the said body,
"politic and corporate: and that the general meetings
"and Council shall have the *entire direction* and *manage-*
"*ment of the same,* in the manner, and subject to the
"regulations hereinafter mentioned."

It is simply begging the whole question to say that "the qualifications for admission into the several ranks of "this Institution are settled by the bye-laws." I was quite aware of this, and the whole object of the paper was to try to induce the members to alter these bye-laws, which, if I understand the constitution of the Institution aright, they have the power of doing.

When the Council say that they "feel that they would
"not be warranted under existing circumstances in ex-
"tending their action beyond the provisions of the Royal
"Charter of Incorporation," it seems to me that, if they

think that the existing bye-laws represent the limit of the power conferred on them by that Charter, they take a very narrow view of it. I have read that document, and I cannot find that any such limit is imposed. The Institution is said to have been founded "for the general "advancement of mechanical science, and more particularly "for promoting the acquisition of that species of knowledge "which constitutes the profession of a Civil Engineer." Nothing is said as to the means to be adopted for attaining that end; everything is left to the members. They are allowed to "alter, vary, revoke or make new and other "bye-laws as they shall find most useful and expedient." The Institution *might* even become an educational body if the members so willed it, as by doing so it would "be "promoting the acquisition of that species of knowledge "which constitutes the profession of a Civil Engineer."

I do not think it advisable that it should do so, but I am of opinion that its influence ought to be exerted in raising the profession of engineering to the same status as that of the other learned professions, but in order to do this it is not necessary "to interfere with or regulate the "*practice* of the profession" as the Council seem to imagine; all that is required is that *admission* to the profession be properly regulated.

Eight or nine years ago the Council of the Institution published a report showing the state of engineering education in Britain and on the Continent.

Was that publication specially authorised by the Charter or the bye-laws, and what was its object? If it was to show the deficiency of English engineering education, as it clearly did, I think this was unkind, unless the Council intended to do something to remedy that deficiency.

Since this paper was written I have read the following paragraphs in the Autobiography of Sir John Rennie, a former President of the Institution of Civil Engineers, and I would recommend them to the attention of his

successor, the present President, and also to that of the present Members of Council.

"The object of the Smeatonian Society was merely a "social gathering in the form of a club, to assemble the "members at dinner at certain times, when they could "discuss in a friendly manner the various subjects con- "nected with their profession, and to endeavour to "obliterate all those rivalries and jealousies which un- "fortunately are too common amongst professional men of "all classes. The Society was to serve as a rallying point "for the profession, and it was believed that when their "members increased sufficiently (for there was little more "than a dozen engineers in the kingdom at the time who "were counted as such) the Society might extend its "usefulness by reading papers, discussing them, and "publishing them regularly to the world, in the same "manner as the already established scientific societies: "this has since been done by the Institution of Civil "Engineers. But I think the time has now arrived when "that Institution should be enlarged, and take a wider "sphere. It has hitherto been confined too much to the "class practising purely engineering works, but the "mechanical engineers now form a body which must "be treated with every deference. It is very true that "the latter are freely admitted into the Institution, but "there seems to be a tacit understanding amongst the "former that they should not attain the honour of becom- "ing presidents and vice-presidents. It is true that the "late Mr. Field, a most distinguished mechanical engineer, "was elected President, and served his time, but this, I "believe, arose more from his having been one of the "earliest members of the Institution than from any respect "due to the particular class of the profession to which he "belonged. Now there cannot be a greater mistake than "this.

"Every member of that Institution, to whatever class

" he belongs, from the moment he is elected should be in " every respect upon precisely the same footing as those " who are now considered the governing class, and the " ablest man should be chosen from each grade as President " or Vice-President alternately, so that each department " should successively occupy the chair. Also, instead of " choosing the President and Council by rotation, according " to seniority, the acknowledged best men in every de- " partment should be chosen as officers. And further, " the Institution thus regulated should have the power of " giving certificates of competency after the candidates for " admission have been duly examined by independent " examiners; and until they have received these certificates " they should not be allowed to practise. This is the rule " in every other learned profession, and there can be no " reason why it should not be adopted by the engineers. " It is the only method by which it can take rank amongst " the learned professions; and as no other requires more " scientific knowledge, or is entrusted with a greater portion " of responsibility or a larger amount of trust, or where " failure becomes more disastrous, it is quite clear that no " man should be allowed to practise it unless he has passed " a proper examination, and has received a certificate of " competency from proper authorities.

" Against this proposal it may be argued, that many " illiterate men, although of great original genius, would " be excluded if their competency were tried by such a " test. My reply is, let them not be tried only by the " ordinary rules of scientific books, but also by the general " principles which the candidate professes, and let those " principles be tested, to prove how far they are in accord- " ance with sound philosophy. A man like Stephenson " or Brindley, although illiterate, may understand these " principles perfectly, and yet may not be able to explain " them. Nevertheless, let him be examined, but in a " different manner from the ordinary routine, and it will

" soon be discovered whether his profession and his prac-
" tice are founded upon true mechanical and philosophical
" principles.

" If these examinations are properly conducted, every
" possible objection will be abolished, and no scientific
" educated engineer, or illiterate person of true scientific
" genius, will be prevented from pursuing the profession ;
" whilst only the speculator and charlatan will be excluded.
" By this means the public will be assured that the works
" for which they subscribe the funds will be conducted in
" the best manner, and most probably to a successful
" termination."

Sir John Rennie was President during the years 1845-6-7, that is fully thirty years ago, and he was evidently a long way ahead of his times. I think, however, that before another period of thirty years has passed, one of three things will have happened, either that the Institution of Civil Engineers will have adopted a course somewhat similar to what is advocated in this paper, or that another Institution will have been started which has adopted this course, or lastly, that Government will have established a central examining body similar to that which is now proposed for the medical profession. The last of these contingencies is very much to be deprecated, and I hope that the second will be rendered unnecessary, by the Institution of Civil Engineers awakening to a proper sense of its duty.

This paper is not given to the public on account of any special merit it may have, or because the proposals therein made are the best possible, but simply that attention may be called to the subjects dealt with, and in the hope that they may be thoroughly discussed.

HENRY DYER.

IMPERIAL COLLEGE OF ENGINEERING,
TOKEI, JAPAN,
January, 1880.

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EIGHT years ago, the Institution of Civil Engineers published an extensive report on the education and status of engineers in the United Kingdom and in Foreign Countries. This was circulated among the members without the expression of any opinion on the part of the Council, it being, doubtless, deemed preferable in the first instance to put them in possession of the particulars, as it was thought that, from the nature of the subject, various and discordant ideas would be entertained regarding it.

I am not aware that any opportunity has been given to the members of expressing their opinions on the subject of the report, or that any recommendations have since been made by the Institution as a body for the education of its future members. No apology, therefore, is required for introducing the subject of the education of engineers. I wish it, however, to be understood that my object is not so much to give prominence to my own views, or to my attempts to carry them into practice, but rather to originate a discussion on the general question. It may be hoped that, as a result of such discussion, some definite steps may be taken by the Institution for placing Engineers in the same position as the members of other learned professions, by defining more clearly their relations to

the public, and by taking steps to prevent unqualified men from using the title of Engineer.

I ought to explain that I write this in Japan, where I have been resident for nearly six years, and that my information as to what has been done in the way of advancing Technical education in Britain during that time is rather meagre. I think, however, it will be found that circumstances have not altered so much as to materially affect any of the statements made in this paper.

Scope of paper.

I need scarcely say that, when I speak of education, I use the word in its conventionally restricted sense, meaning the training which a student should receive to enable him to perform the duties of assistant engineer in an intelligent manner. This training is only an introduction to his real education as an engineer, and its object should be to give him a good start in the path which he must continue through life. The second part of a man's training must be decided almost entirely by the special circumstances under which he is placed, and by his own ability and perseverance; but I think that the first ought to be systematised to a greater extent than at present.

Preliminary training of the students.

The first necessity for engineering, as for other professions, is of course that the student should have a good elementary English education. By the time he is sixteen he ought to have mastered the ordinary branches, with the addition of elementary mathematics, physics, and drawing, and, if possible, one or two modern languages. I think this is not expecting too much from the student, but I would strongly deprecate any attempt at high pressure, forcing and continual grinding, for competitive examinations. The freshness and vigour which should be stored up for the hard struggle in life is by such a system washed out of him, and he is apt to degenerate into a mere book-worm, wholly awanting in that manliness of thought and action which is the chief characteristic of a successful engineer.

I am sure to be supported by the majority of English engineers when I say that no system of education is likely to be successful in England which delays for a long time the entrance of the student into practical work, and, by the time he is twenty-two years of age, fails to fit him for a position to act as a qualified assistant. I do not propose to improve the education of engineers by increasing the theoretical part of their training at the expense of the practical; I wish rather to systematise the former, so that the student may be able to take a more intelligent view of the latter.

Course proposed.

Let us suppose, then, that we have a student at the age of sixteen, and consider how his time ought to be employed for the next six years. I would propose that, for the first three years, he should spend six months of each year at College and six months at works, and that for the remaining three his time be taken up almost entirely with practical work. My own observation has shown me that a student who enters the workshops early in his career makes much more rapid and solid progress at College than one who is entirely ignorant of mechanical details, and also that, if theoretical studies are carried on alternately or concurrently with practical work, a more intelligent view is taken of that work.

The course at College during the first three years for Civil and Mechanical Engineers would be somewhat as follows:—

Civil Engineers.	Mechanical Engineers.
FIRST YEAR.	FIRST YEAR.
Mathematics.	Mathematics.
Natural Philosophy.	Natural Philosophy.
Chemistry.	Chemistry.
Geology.	Geology.
Drawing Office.	Drawing Office.

Civil Engineers.	Mechanical Engineers.
SECOND YEAR.	SECOND YEAR.
Applied Mechanics.	Applied Mechanics.
Machinery (descriptive).	Machinery (descriptive).
Drawing Office.	Drawing Office.
Surveying.	Engineering Laboratory.
THIRD YEAR.	THIRD YEAR.
Special Construction, *e.g., Roads, Railways, Harbours, Canals, &c.*	Machine Design.
	Prime Movers.
	Engineering Laboratory.
Civil Engineering Design.	Drawing Office.
Engineering Laboratory.	

It will be observed that these two courses are nearly the same for the first two years, and that it is only in the third that the studies are specialised. If the student can remain another year at College, it would be a great advantage to him to take the courses for both Civil and Mechanical Engineers, but I think it would be found that comparatively few would extend their College career beyond the third year, and in my opinion it is better to specialise the studies, rather than allow the student to leave with the merest smattering of the theory of the branch he intends to follow. The subjects mentioned above agree in great part with those in the courses of some of the British Colleges, and as I will afterwards point out, these only require to be carried out in a more thorough manner, to supply all that is wanted.

In the above courses the pure sciences only occur in the first year, as I have taken it for granted that the student entered College with a fair knowledge of elementary mathematics, and some notions of physical science, and I think this would be sufficient for the *ordinary* course, which ought to be almost entirely independent of the higher mathematics.

It must not be imagined, however, that I wish to reduce all the students to the same level as regards purely scientifio attainments.

For those who have the wish and the ability, I would propose that a higher course of theoretical training be arranged *after they have completed the six years*, when they will be in a position to see the applications of their higher studies, and also when they will be less likely to allow their mathematics to run off with them. A great many students learn their mathematics in a purely mechanical way; they can differentiate and integrate, and solve all sorts of mathematical puzzles, but they have not the slightest idea of the physical meaning of the results. They put the problem into the mathematical mill, give the handle a few turns, and send out an alarmingly long formula, the meaning of which is quite beyond them.

I quite agree with Professor Kennedy, when he remarks:—"I have no hesitation in saying, that a man's "knowledge of mathematics ends, exactly where his ability "to work problems ends; anything beyond that is useless, ".so far as his profession goes, and is even liable to have, "in certain cases, disastrous consequences."

Professor Huxley, in an address on medical education, says:—"I entertain a very strong conviction, that any one "who adds one iota or little beyond what is absolutely "necessary is guilty of a very grave offence, and further, "that it is, in my (his) belief, a downright cruelty, to require "from gentlemen who are engaged in medical studies, a "pretence, for it is nothing else, and can be nothing else "than a pretence, of a knowledge of comparative anatomy, "as part of their medical curriculum." So with regard to engineering, I would say it is unjust to expect the students to study subjects which they are unable to apply to their profession.

If they have time, inclination, and ability, these should be taken up, but only for a special scientific degree, and

their professional studies should not be cumbered with them.

Drawing.

The drawing office figures largely in the courses I have suggested. I do not for a moment propose to supersede the necessity for actual experience in an engineer's office, but in my opinion, no system of preparatory training should be considered complete in which the student is not to apply graphic methods to the solution of problems, and to design engineering works and machines to suit given conditions. No mere copying of drawings should be allowed. Everything ought to be done either from models, the actual machines or works, or from rough sketches and notes supplied by the teacher. Professor Fleeming Jenkin gives the following account of the work done in the drawing offices of the Continental schools, which shows clearly what can be accomplished in the way of preparation for the actual work of an engineer's office: "The pupil begins by designing screws, bolts, rivets or "walls and culverts, and ends by designing, under the "master's eye, the most complex machines, and the most "elaborate bridges and harbours; he is shown the practice "of all nations, he is forced to calculate his work, so as to "meet the requirements of real problems, and so thoroughly "is this done that students do leave their Colleges well "able to earn a good salary in the drawing office of the civil "and mechanical engineer. I could not have believed this "to have been possible had I not seen it, and my personal "inspection of the Colleges taught me to marvel at the "combination of theoretical with practical knowledge "evinced by the German Professors. At the École Centrale "I found the system was similar; in addition to the usual "courses of lectures, projects were each month submitted to "each class, that is to say, they received a short specifica-"tion of a certain work to be designed. The designs, "specifications, and estimates were to be ready in one "month's time. Meanwhile each pupil was free to consult

"books, friends, even the Professor himself, but he was "bound to produce an original design, making the "drawings in the class-room. When each design had "been sent in, the Professor cross-examined every pupil as "to his motives for choosing the dimensions, materials and "forms adopted, and finally he corrected and criticised the "design."

Engineering Laboratory.

It will be observed, that in the above courses I have included work in the Engineering Laboratory, and this I consider of the utmost importance. The education of an engineer must be considered incomplete if he does not know how to test the qualities of the materials with which he has to deal, to measure the work required for different purposes, and to observe and measure everything connected with steam engines and boilers, in short, unless he is something of a physicist as well as an engineer. This part of an engineer's training is just beginning to receive attention in England, though in Germany an engineering laboratory has long formed an essential part of every well equipped College.

Of late a considerable amount of discussion has taken place as to the position to be given to original investigation, in scientific education.

There can be no doubt as to its value as a means of education, but in my opinion, the first duty of engineering students is to make themselves acquainted with what is already known of their subjects, and this is more than enough to keep them fully occupied during the time the most of them can spend at College. For those who have the time, inclination and ability a post-graduate course ought to be arranged, and opportunities given for original research.

Teacher required.

For carrying out in an efficient manner the work of the second and third years, a staff something like the following would be required:—

1st. *Professor of Applied Mechanics*, who would teach

both classes of students those fundamental notions that are the foundations of both Civil and Mechanical Engineering. Rankine's or Weisbach's treatises may be taken to represent the scope of his lectures, but the methods adopted would be much simpler, and special attention paid to graphic methods of solution, and to illustrations and examples.

2nd. *Professor of Civil Engineering*, who would teach by lecture and in the drawing office the applications of Mechanics to such questions as arise in the practice of Civil Engineering. Rankine's treatise on Civil Engineering may be taken to represent the scope of his lectures, but special reference should be paid to practical details and to designs of works on prescribed conditions.

On each subject upon which he lectured, he would supply the students with a list of authors, to whom reference could be made for further information, and to descriptions of works which had been carried out.

3rd. *Professor of Mechanical Engineering*, who would instruct the students in machine design, and in the theory of prime movers. Rankine's treatises on Machinery and Millwork and Prime Movers may be taken to represent the scope of his lectures, but the instruction given would be of a more practical nature. He would also give descriptive lectures on different classes of machines, referring to standard works for further details.

4th. *Instructor in Surveying and Civil Engineering*, who, under the Professor of Civil Engineering, would give instruction in surveying: superintend actual surveys and assist the students in the drawing office with their work: in short, act as class tutor to the Civil Engineering students. I do not think it necessary that the surveying course should be very extensive, as the student will have sufficient practice when he enters an engineer's office.

5th. *Instructor in Drawing and Mechanical Engineering*, who under the Professor of Mechanical Engineering would

assist in the drawing office, and act as class tutor to the Mechanical Engineering students.

At present, in the majority of British Colleges, the whole of this work is undertaken by one Professor, or at most, by a Professor and an assistant. I am sure I will be supported by these Professors when I say, that the courses are not nearly so complete as they ought to be, and cannot be improved without such additions to the staff as I have indicated. What I have proposed is a very small staff compared with what we find in German technical schools, but I think it would be sufficient, as it would be impossible for the students to attend more classes in the time we have fixed for the length of the course.

Special Lectures.

I would propose, however, that during their practical course they should attend special evening lectures, by men who have had large experience in one branch of engineering. These lectures would be of the greatest value to the students, as embodying the latest practice in that branch of the subject, and I think that in almost all the large towns in Britain, men could be found who would be willing to give the results of their experience.

Associations.

At the same time the students ought to be encouraged to form associations for the reading of papers on engineering subjects, and for discussion. In London the students' section of the Institution and different associations give all the opportunities required, but similar arrangements should be made for the students attending the Colleges in the various cities.

Diploma.

To those who complete the prescribed course of study, and attain the required standard, the College ought to give a degree in science, and show clearly by the name that it makes no pretence to having examined the student in the practical part of his profession. I think for a College, by *itself*, to give a student a diploma as a civil or mechanical engineer is simply absurd, as such knowledge as is to be obtained at College is not sufficient to justify the bestowal of these names.

Workshop course.

During the half of each of the first three years, I would propose that both the Civil and Mechanical Engineering Students be employed in the workshops of a Mechanical Engineer, as ordinary apprentices, doing the same work, and receiving the same pay. I would specially insist on these two points, because I have always observed that unless this arrangement is made, they, as a rule, simply waste their time and come to be looked upon as nuisances in the workshop, whereas if they are given to understand that unless they attend to their work, their presence will not be tolerated, at the end of the third year they are sure to be fairly good workmen.

Pupilage or Apprenticeship.

Having obtained his College diploma, the Civil Engineering Student should enter the office of an engineer in active practice, and make the best use he can of such experience as falls to his lot, while the Mechanical Engineer should remain in the workshops for about another year, and then finish his course in the drawing office and counting house. I have already pointed out that, during these three years, the students might extend their knowledge by attending lectures on special subjects, and the meetings of associations for the reading and discussion of papers, but, in addition to that, they ought to take every opportunity of reading accounts of works that have been executed or machines that have been made, such, for instance, as are included in the transactions of the Institution of Civil Engineers and in the periodical literature.

Examination in practical subjects.

At the end of the sixth year, the students should be examined in the application of their knowledge to practice, and receive a diploma from a properly qualified examining board. As to the nature of this examination, and the constitution of the examining board, I will speak further on.

Short description of the course of study in the Imperial College of Engineering, Tokei, Japan.

In the meantime I will give a short account of how I have attempted to carry out my views with regard to engineering education in Japan. For complete details I would refer to the calendars and reports of the Imperial

College of Engineering, copies of which will be found in the library of the Institution of Civil Engineers. As I have already explained, my object in referring to this College is simply for the purpose of illustrating the views I have already enunciated, and not to hold it up as a pattern in any way. In the very peculiar circumstances of Japan and the great difficulties in the way of carrying out any system of education, it will be a good many years before the College is fully developed.

This College was established for the purpose of providing engineers for service in the Public Works Department. As this department includes, not only what are generally considered the usual branches of engineering, but also various manufacturing arts, the word "engineer" had to be taken in a somewhat wider sense than that in ordinary use. In reality, the College consists of a combination of schools, corresponding to the different sections of the Public Works Department. These are:—

1st. Civil Engineering.
2nd. Mechanical Engineering.
3rd. Telegraphy.
4th. Architecture.
5th. Chemistry and Metallurgy.
6th. Mining.

We will at present enter into details of only the first two, as being more immediately connected with the subject of this paper. The method of instruction in the others is, *mutatis mutandis*, the same, and for details I would refer to the calendars and reports already mentioned.

Entrance examinations.

The students are admitted to the College by competitive examination, about fifty being admitted annually. The subjects of examination are:—

1st. Translation from Japanese into English.
2nd. Translation from English into Japanese.
3rd. Writing to Dictation.
4th. English Grammar and Composition.

5th. Arithmetic.
6th. Geography.
7th. Elementary Geometry.
8th. Elementary Algebra.

The candidates have generally been fairly well prepared, none being admitted unless they gained fifty per cent. of the obtainable marks, but there is still room for improvement, without which it will be impossible to do justice to the technical subjects.

General course.

During the first two years the students are engaged wholly at College. At first I intended that they should spend six months of the year at College and six months at work, but by reason of their defective knowledge on entering, the present arrangement has been made in order to allow more time for the general and scientific course, the subjects of which are :—

1st. English Language and Composition.
2nd. Geography.
3rd. Elementary Mathematics.
4th. Elementary Mechanics.
5th. Elementary Physics.
6th. Chemistry.
7th. Drawing—Geometrical and Mechanical.

All the students must pass an examination in the subjects of the general and scientific course, and obtain an average of at least fifty per cent. of marks, over all the subjects, and a minimum of thirty per cent. in any one subject, before they are allowed to enter upon the technical courses they have selected.

Technical courses.

During the third and fourth years the students spend half their time at College and half at practical work. The following shows the course of study pursued during this period :—

CIVIL ENGINEERING.

Pure Science.	Practical Applications.
Higher Mathematics.	Surveying.
Higher Natural Philosophy.	General Construction.
Applied Mathematics.	Machinery.
Geology.	Prime Movers.
	Workshop Construction.
	Special Construction.

Work.

Drawing Office.
Technical Museum.
Engineering Laboratory.
Practical Surveying.
Laying out Works.
Excursions.

MECHANICAL ENGINEERING.

Pure Science.	Practical Applications.
Higher Mathematics.	General Construction.
Higher Natural Philosophy.	Machinery.
Applied Mathematics.	Prime Movers.
	Workshop Construction.
	Hydraulic Engineering.

Work.

Drawing Office at College.
Technical Museum.
Engineering Laboratory.
Drawing Office at Akabane Works.
Excursions.

During the summer sessions of the third and fourth years the Civil Engineering students are engaged in surveying roads, railways, harbours, &c., and in making designs for the works. In selecting the positions for works, we give the preference to those which are likely shortly to be carried out, so that the students will have an

opportunity of comparing their designs with the actual works.

The Mechanical Engineering students, during the same time, are engaged in the drawing office and pattern shop in an extensive engineering establishment at Akabane, which is connected with the College and of which I will speak further on.

Teachers employed.

For carrying out the technical course for Civil and Mechanical Engineers we have—

Two Professors of Engineering,
Two Instructors in Drawing,
One Instructor in Surveying and Civil Engineering,
One Instructor in Mechanical Engineering.

This is as large a staff as we can expect the Japanese Government to provide at present. When some of our best students have finished their courses and become executive officers of the Public Works Department, they will also act at College as Lecturers on their special branches, and thus we shall be able gradually to extend the courses. As the elementary education of the country improves, I hope to be able to finish the general and scientific course in one year, thus giving more time to the technical part of the studies.

Drawing offices.

To show the importance that I attach to drawing, I may mention that we have four drawing offices, viz. :—

1st. The General Drawing Office, where all the students go through a course of Practical Geometry and an elementary course of Technical Drawing.

2nd. The Engineering Drawing Office, where the Civil and Mechanical Engineers go through a course of Designing and learn to apply practically what they have heard in the Lecture-room, by making working and finished drawings to suit given conditions.

3rd. The Surveying Drawing Office, where almost all the students plot surveys made by themselves.

4th. The Architectural Drawing Office, where the

students of Architecture make drawings in application of the lectures by the Professor. Here also the Civil Engineering students go through a short course of architectural drawing, sufficient to enable them to make designs for such buildings as are required in ordinary engineering practice.

In these offices mere copying is, as far as possible, discouraged. The drawings are generally made either from notes and sketches furnished by the Professor, from models, or from the actual machines or works. Some of the most advanced students make designs of apparatus for original investigations, and carry out these investigations in the Engineering Laboratory. Even in those branches in which drawing is not usually considered of much importance, such as chemistry, telegraph engineering, &c., all the students go through a special course of designing, to enable them to make working drawings of the apparatus or works on which they may hereafter be engaged. I have always considered that the great deficiency in every scheme of Engineering Education in any British College with which I am acquainted is, that the students have not sufficient practice in Drawing to enable them to put their designs clearly on paper, and the course of this College has been arranged to obviate this deficiency as far as possible.

Technical Museum.

A Museum containing models of Engineering Works and Machines I consider not only a great assistance to the students, but a necessity to the Professors, as it is impossible for them to explain in an intelligible manner any complicated mechanism without a well-made model of it. In Japan especially, such a museum is of the first necessity, as the students have not the slightest idea of the actual shapes of the various parts of the machines. Considering the comparatively short time we have been at work, we have now a very extensive Museum, illustrating the various subjects taught at College, and a good many of

the models have been made on the premises. A catalogue of the museum will be found in the calendar already referred to; and of the Library, which now contains a fair collection of the best books on the various subjects.

Engineering Laboratory.

Ever since the College was founded, I have kept in view the necessity of having an engineering laboratory in connection with it, where such experiments might be carried out as are necessary in guiding the constructive engineer in his work. For the first four years this establishment was used principally for the making of models and instruments, but I am gradually transforming it into a place for conducting experimental work. Hitherto the students have not had much time for such work; but I hope that some of our most advanced will soon be able to undertake useful investigations.

The laboratory contains a few of the ordinary mechanic tools, a large testing machine which was designed and made at College, a Thurston's testing machine, various hydraulic presses, oil-testing machines, brakes and dynamometers, counters and indicators, and a complete set of apparatus for weighing and measuring and for graduating scales. The steam engine and boiler at present in the laboratory are not specially suited for experimental purposes; but still, in addition to driving the machines, they are used to show the students how to take indicator diagrams, to use counters and dynamometers, and for experiments with steam generally. I hope in the course of time to make an engine and boiler specially suited for experimental purposes, and so arranged that the efficiency of each part may be exactly measured.

Examination.

At the end of the fourth year, the students require to pass an examination in the subjects of the Technical Course. If they attain the required standard, they are, during the fifth and sixth years, employed almost entirely in practical work, under some properly qualified engineer.

The Civil Engineers go for a short time to Akabane to

learn the use of tools, then to the Railway, the Lighthouse, or other section of the Public Works Department; whilst the Mechanical Engineers will, for the most part, finish their course under my direction at Akabane. They are required to send in reports of the works on which they have been engaged, and, before receiving their diplomas at the end of their sixth year, they must make out complete working and finished drawings of an engineering work or machine, with an essay on the principles and practice of the subject selected, and, in addition, pass an examination on the works with which they have been engaged.

The following are the subjects suggested for the exercises for next year, but the students may select any other on the approval of the Professor :—

Civil Engineers.

1st. Specifications and Drawings for a line of Railway, not less than ten miles in length, with an Essay on Railways.

2nd. Specifications and Drawings for a Road, not less than 10 miles in length, with an Essay on Roads.

3rd. Specifications and Drawings for *two* Lighthouses, with an Essay on Lighthouses.

4th. Specifications and Drawings for the proposed Harbour at Akita, with an Essay on Harbours.

5th. Specifications and Drawings for the Improvement of any of the Rivers of Japan, with an Essay on River Improvements.

6th. Specifications and Drawings for—

1st. A Suspension Bridge,

2nd. An Arched Bridge,

over the Sumida River, with an Essay on Iron Bridges.

Mechanical Engineers.

1st. Complete working and finished Drawings and Specification of a Stationary Engine, with an Essay on Stationary Engines.

2nd. Complete working and finished Drawings and Specification of a Marine Engine, with an Essay on Marine Engines.

3rd. Complete working and finished Drawings and Specification of a Locomotive Engine, with an Essay on Locomotive Engines.

4th. Complete working and finished Drawings of various kinds of Water-wheels and Water-pressure Engines, with a descriptive Essay.

5th. Complete working and finished Drawings of at least *three* Machine Tools, with a general Essay on Machine Tools.

6th. Complete working and finished Drawings of Machinery used in some Manufacture, with an Essay describing the machinery and explaining fully the different processes of the manufacture.

Those who produce the required exercises, and pass the necessary examinations, and who have attended regularly to their practical work, will receive diplomas, and be appointed assistant engineers in the Public Works Department.

Higher course of study.

For those who distinguish themselves in the ordinary course, I propose to arrange special courses of study in the branch of engineering they intend to follow out; and they will remain at College for one, two or three years longer, as circumstances may demand, and pursue these higher studies under the direction and with the aid of the Professors, and carry out original investigations in the physical and engineering laboratories.

These will receive the higher appointments of the Public Works Department. The best of them, however, will be sent to Europe or America for the purpose of enlarging their experience, and preparing themselves for becoming Professors of their subject, or for taking charge of some special manufacture.

We will thus provide three classes of men: first, the

ordinary officers of the department; second, those who are able to take leading parts; and third, those who are qualified to advance science. I think every one will agree with me, that it is better to arrange to meet the capacities and wants of all, rather than to have one uniform standard, which might either be too high and prevent students from entering the College, or too low and be practically worthless.

Akabane Works.

I may explain that the works at Akabane, though connected with the College and under my management, are not to be classed with the establishments sometimes found in connection with Colleges, where the students amuse themselves by playing at engineering, but are *bonâ fide* engineering works, where everything is carried on as if they belonged to a private firm, and differ only from similar works in England by the great variety of work done, and in the difficulties to be overcome on account of the want of skilled labour and suitable materials and machines.

The machines and fittings are of sufficient size to turn out as heavy work as is likely to be required in Japan for some years.

The number of workmen employed averages about 300 and the receipts for work done per annum from £20,000 to £30,000.

The students are put into these works, and are subject to the same regulations as the ordinary apprentices. For details of the work done at this establishment, I refer to the Calendars and Reports already mentioned.

Progress made.

As our most advanced students are only in their sixth year, and have not yet received their diplomas, it is still too early to speak of results; but, so far as we have gone, the progress has been very satisfactory, and I have not the slightest hesitation in saying that at the end of their course these men will be able to act as useful assistant engineers.

In Japan, from the circumstances of the country as

regards education and public works, it was necessary to institute a special establishment for the training of engineers; but in Britain, if the old-established Colleges do their duty, or, perhaps, to be more just to them, if they are enabled to do their duty, I would deprecate the institution of special technical establishments for the training of engineers. Of course several new Colleges would require to be founded before the system of education would be complete; but these should combine classes for general culture; and purely scientific training, with the more strictly technical attainments required by an engineer. I would mention Owen's College, Manchester, as a type of the new Colleges required.

I have no doubt that this proposal will meet with opposition from those who think that it is not the business of a College or University to give technical instruction, but I would ask, What could be more strictly technical than the training of divinity, law, or medical students in the existing Colleges? They do not learn the actual practice of their profession, but are taught everything to fit them for that practice; and this is all I ask for engineers. No School or College should attempt to teach the students the practice of engineering, though it would be a great convenience if such a connection could be established with works as exists between Colleges and Hospitals. The works at Akabane being under my management, there is the same connection with the College as exists when a medical man is Professor of the Practice of Medicine in a College and Physician in an Hospital; but in England such a connection would seldom exist, nor do I think it very desirable that it should. The Professor ought to have more leisure for private study and investigations than he would have if he had all the cares of the management of an engineering establishment; and in England I would never think of accepting the double position: I only do so in Japan because special circumstances require it.

I think, however, that in Britain there would be no difficulty in obtaining permission for the professors and students to visit the works in the neighbourhood of the College; and I have proposed that, during the summer, the students should enter the works of a mechanical engineer, and be kept strictly to their duties.

When I recommend that the technical training of engineers should be given in colleges in which a general education is also given, I agree with the resolution of a Committee of the Society of Arts; but when a Committee goes on to say, that * "what is required " is that students should enter on their pupilage as well " instructed as foreign students enter the special schools " of the Continent," I entirely disagree with it. What the pupils want is not such an amount of theoretical knowledge, but rather that they should be able to apply comparatively elementary mathematics to the problems of every-day life. A first-class mathematician entering an engineer's office or workshop would, for a long time, be of little use; he would be likely soon to forget his mathematics, since he had not learnt to apply them, and he would be of less value than an ordinary apprentice, as he would be probably more conceited.

As an example of the *style* of instruction which a mechanical engineering student should receive, I would mention Professor Unwin's little book on "Machine Design," which is as nearly perfect as could well be expected. If books of this type were a little more common in Britain, the study of engineering would be greatly facilitated.

The College course which I have proposed will be generally finished by the time the student has completed his nineteenth year; and, as this is the average age for students entering the Polytechnic School of Paris, it will be seen that I do not propose to adopt the Continental system, but rather prepare the students for their pupilage

* See "Inst. of C. E. Report," p. 193.

or apprenticeship, which is omitted altogether on the Continent.

This pupilage or apprenticeship, I propose, should be of three years' duration, in addition to the summers the student has already had at work. After the preparation he has had, he will learn more in one year spent at practical works than in double the time without it; so that by the time he has completed the proposed course, he will have as much practical knowledge as if he had spent his whole time in the workshop or on works.

Examination in practical subjects.

Having completed his practical course, the student ought to be examined by a board of engineers; and, if he attains the required standard, he should receive a diploma. In my opinion this examination should be conducted under the auspices of the Institution of Civil Engineers, which would be able to supply a greater variety of examiners than if it were conducted by any Government Department, such as, for instance, that of Science and Art.

That department is doing a great work, but it is open to the same objections as all attempts at the centralization of education or examination, that is, too great uniformity in the work done and questions set, and, consequently, too great uniformity in those examined.

We do not want engineers who would be merely small editions of some examiners, as they were to be seen in their writings, but rather men capable of independent thought and action. If the Institution appointed a large Committee from among its most distinguished members, there would be sufficient guarantee that the work would be well done, and that there would be a great variety in the papers and exercises set. Of course, as each student is supposed to possess a College Diploma, there would be no necessity for examining in the more theoretical parts of the subject, so that the examinations undertaken by the Institution would be of a thoroughly practical nature. I would propose that each examination should consist of

two parts, the first being to test such general practical knowledge as all engineers ought to possess, and the second having special reference to the branch of engineering selected by the candidate.

Thus, for Civil and Mechanical Engineers I would suggest some such scheme as the following :—

CIVIL ENGINEERS.

I. General papers.

II. Special papers, with designs, calculations, specifications and estimates on any *one* of the following branches.

(*a*). Roads and Railways.
(*b*). Harbours.
(*c*). Rivers and Canals.
(*d*). Water-works.
(*e*). Lighthouses.

MECHANICAL ENGINEERS.

I. General papers.

II. Special papers, with designs, calculations, specifications and estimates on any *one* of the following braches :—

(*a*). Stationary Engines.
(*b*). Marine Engines.
(*c*). Locomotive Engines.
(*d*.) Machine Tools.
(*e*.) Machines and plant for special manufactures.

Each candidate should be required to hand in a finished drawing of some machine or structure, in order to show that he is a good draughtsman. If he has time to extend his apprenticeship beyond the three years I have mentioned, he may be examined in more than one special subject (this fact being mentioned in his diploma), but it is absurd to expect from engineering students the pretence of a practical knowledge of all the branches of engineering to be gained in an ordinary apprenticeship.

These examinations should be of a most thorough nature, and should last for at least a fortnight, in order that the candidate might have time to do his work in a proper manner. I would strongly recommend that he be allowed the use of a few standard works of reference during the examinations; in fact, that he should be placed under the same conditions as he would be in an engineer's office. Examinations as at present conducted test none of the qualifications of an engineer, excepting a retentive memory and a certain aptitude for figures. The candidate is simply required to cram into his head facts and figures by the dozen, a short time before the examination day, and when he has got the necessary number stored up, he merely requires a mechanism so arranged that he can place them on paper at will, and be done with them for ever. He does not even require to understand what he writes, so long as he simply reproduces what he has read or heard. I hope if this Institution inaugurates examinations, they will be of such a nature as to discourage mere cramming.

Appointed Graduate; afterwards Member.

Having obtained his diploma for practical work, the student should be appointed a graduate of the Institution, and, after four years' further practice, he should be transferred to the class of Members. The Associateship should, in my opinion, be reserved for persons not engineers by profession, but who, by their connection with science or the arts, are qualified to concur with engineers in the advancement of professional knowledge. I think this system of supplying Members to the Institution would be more satisfactory than the somewhat hap-hazard method now employed. As at present arranged, the Membership is not a guarantee that the holder of the title is a properly qualified engineer; it is rather a certificate to the effect that he has held a certain position for a certain length of time; but what would be thought of any system of licensing medical men after a normal apprenticeship and five years' practice?

On those Members of the Institution who acted as examiners I would bestow the title of Fellow, and make it a real honour by only awarding it to those who were distinguished in their profession. I think these Fellows should be elected by the Council, and perhaps in addition it might be advisable to bestow the title on all present and past members of Council. Examiners to be called Fellows.

The Council should also have the power of electing, as Members, men who had distinguished themselves in the profession, but who had not gone through the course indicated above. Some of our greatest engineers have been self-taught, and there is no reason for believing that no more George Stephensons nor Rankines will arise, who will do more to advance engineering than all the other men of their generation put together, but whose training has not been such as to satisfy any rigid programme. I hope the Institution will make arrangements which will keep it from again being disgraced, by declining to allow such men to be enrolled among its Members. Special election of Members by the Council.

To prevent the possibility of the Council abusing its power of election, the Members should have some control. What this ought to be is a matter of detail, and could be settled at a General Meeting.

The subject of the education of engineers would not be complete unless I mentioned that of the higher class of artizans. I cannot do better than quote a few sentences from a lecture by Professor Huxley on this subject: "There "is another reason to which I have already adverted, and "which I would reiterate, why any extension of the time "devoted to ordinary school work is undesirable. In the "newly awakened zeal for education we run more risk of "forgetting the truth that while under-instruction is a bad "thing, over-instruction may be possibly more. Success "in any kind of practical life is not dependent solely, nor "indeed chiefly, upon knowledge. Even in the learned "professors knowledge alone is of less consequence than Education of the higher class of artizans.

"people are apt to suppose, and if much expenditure of "bodily energy is involved in the day's work, mere know-"ledge is of still less importance, when weighed against "the probable cost of its acquirement. To do a fair day's "work with his hands, a man needs above all things health, "strength, and the patience and cheerfulness, which, if they "do not always accompany these blessings, can hardly in "the nature of things exist without them, to which we "must add honesty of purpose, and a pride in doing what "is done well. A good handicraftsman can get on very "well without genius, but he will fare badly without a "reasonable share of what is a more useful possession for "work-a-day life, namely, mother-wit, and he will be all "the better for a real knowledge, however limited, of the "ordinary laws of nature, and especially of those which "apply to his own business.

"Instruction carried so far, as to help the scholar to turn "his store of mother-wit to account, to acquire a fair "amount of sound elementary knowledge, and to use his "hands and eyes, while leaving him fresh, vigorous, and "with a sense of the dignity of his own calling, whatever "it may be, if fairly and honestly pursued, cannot fail to "be of invaluable service to all those who come under its "influence. But, on the other hand, if school instruction "is carried so far as to encourage bookishness, if the ambi-"tion of the scholar is directed not to the gaining of "knowledge, but to the being able to pass examinations "successfully, especially if encouragement is given to the "mischievous delusion, that brain work is in itself, and "apart from its quality, a nobler or more respectable "thing than handiwork; such education may be a deadly "mischief to the workmen, and lead to the rapid ruin of "the industries it is intended to serve. I know that I am "expressing the opinion of some of the largest, as well as "the most enlightened employers of labour, when I say "that there is a real danger that from the extreme of no

"education, we may run to the other extreme of over "education of handicraftsmen, and I apprehend that what "is true for the ordinary hand worker, is true for the "foreman. Activity, probity, knowledge of men, ready "mother-wit, supplemented by a good knowledge of the "general principles involved in his business, are the "making of a good foreman. If he possess these qualities, "no amount of learning will fit him better for his position, "but may in various direct and indirect ways, act as direct "disqualifications for it."

I am of opinion that if a boy leaves school at the age of 13 or 14 years, with a good knowledge of the three R's and a little mathematics and physical science, he ought to obtain sufficient technical knowledge for the position of foreman or leading man, by attending properly conducted evening classes and by private reading and observation.

It must be remembered that the first duty of a boy of the artizan class is to do something towards earning his living, and it is useless to propose any scheme of education which prevents him from doing this, beyond the age I have named.

College course ought to attract the best of the artizan classes.

The order of the course of study and practice for Civil and Mechanical Engineers which I have given above, is such as would be taken by persons whose parents are in a position to pay for a College course, but if the artizan classes really saw that such a course would be of use to them in advancing their position, I have no doubt they would largely take advantage of it, but in the reverse order to what I have described above, that is, they would serve their apprenticeship first, and then attend College. Those who were really anxious to do this would have little difficulty, as they would be able to save sufficient money in the summer, to keep them at College in the winter time.

Of course by the time they received their diploma from the examining board of the Institution, they would be a few years older than the first class of students, but this

would be rather an advantage than otherwise, as they would have had more practice, and I think it would be found that the best engineers would come from the artizan class, as they would have more self-reliance, energy, and determination.

Too often we find that the students who attend colleges at present, or who are premium apprentices at work, are simply being *made* into engineers by the orders of their parents, who seem to think that a little turn for making toy-models augurs well for their success in the profession, but a great many of these students have no heart in their work. How different it would be, if these Colleges could attract men, who, having finished their apprenticeship, were determined by their own perseverance and energy to fight their way into the higher ranks of the profession.

The high standard attained by the Admiralty students of the Royal School of Naval Architecture (now incorporated with the Royal Naval College, Greenwich) shows what may be done by artizans after they have finished their apprenticeship, if they have had opportunities for extending their theoretical and practical knowledge. I am quite aware that these Admiralty students have special advantages, but I think that properly organised evening schools would give the same advantages to private students of the artizan classes; and I am of opinion that any system of education which does not attract the best men among these classes must be pronounced a failure, either as to arrangements, to the methods adopted, or to the subjects taught.

Proposed technical University.

Some eminent persons have, I understand, lately recommended the establishment of a central technical university, but I think this is even more objectionable than having a Government department to superintend the final examination. Uniformity in teaching and examination would soon have the same effect in Britain as it has had in China, that is, stagnation, through extinction of progress.

I remember a sentence by my late teacher, Professor Rankine, to the following effect: "It is good to leave the "various schools of science to be managed each by its own "free and independent authorities, in order that there may "be diversity and competition, and advancement in science "and improvement in practice; and it is right to resist all "attempts towards bringing the scientific endowments of "the nation under the control of one department of the "Government, as a measure which is certain to lead to dog-"matism and mental servitude, and to stagnation of art "and science."

The Council of the Institution of Civil Engineers, in protesting against the foundation of a special College for the training of Engineers for India, said: "In the pro-"posed College the minds of the pupils will all be "moulded in the same forms. There will be none of the "emulation of different schools of thought and action, "and none of that independence and originality of "resource which have produced the best engineers."

It is no reproach to the excellent staff of Cooper's Hill College, when I say that in my opinion the Government made a mistake in founding this College, for the reasons given above, and also as the Council further remarked, "because the duration assigned to the practical training is "insufficient to prepare the students properly to fulfil the "duties of assistant engineers, and they will therefore be "reduced to the necessity of learning their profession by a "system of trial and error, at the expense of the people of "India." If the Government, instead of founding this College, had enabled those already in existence to extend their courses, and had at the same time insisted on the students serving a *bonâ fide* apprenticeship, candidates for service in India would have been obtained, who would have turned out more useful engineers than those trained by the present system.

Training of Professors and Teachers.

It has been urged that a Central University is necessary for the proper training of Teachers of technical science, but the objections against uniformity of teaching and examination apply with equal force to uniformity in the training of teachers; in fact, the latter is likely to lead to the same result as the former. If every graduate of a College had the right of teaching, or to speak more correctly, if he were allowed to exercise a right which is already his, and if such classes were recognised as qualifying for the examinations, and if the Professors appointed some of their best students as assistants and instructors, such an office only being tenable by the same person for three years at most, there would soon be a sufficient supply of properly trained teachers to carry on any system of technical education which might be inaugurated. A great part of the actual teaching might safely be given over to these lecturers and instructors, leaving the Professors free for the higher courses, and for original investigation. I think this would be a satisfactory way of endowing research, as research and teaching should never be entirely disconnected, but the Professor might with advantage be relieved of a great part of the ordinary routine work of the class.

Pressure must be applied.

It may be said by some that it is useless proposing to extend the opportunities for the education of Civil and Mechanical Engineers, seeing that so few students, comparatively speaking, take advantage of the classes already in existence, but a little consideration will show that this argument has no force.

How many students would attend the Medical Schools if they had only one Professor who attempted all the branches of the subject, or if they could practise as physicians or surgeons without undergoing any test as to their qualifications? I think very few. This, however, is precisely the position of engineers. There are no fully organised Colleges, and anyone who chooses may call himself an engineer.

If the Institution made it a rule that (after a certain number of years) no member would be admitted (except in such special cases as I have mentioned), unless he possessed a diploma from some College, or passed an equivalent examination in pure and applied science; and, in addition, had served an apprenticeship of at least four-and-a-half years in practical work, and passed an examination, in subjects relating to the practice of engineering, by a committee appointed by the Institution, there would soon be sufficient students to justify the establishment of a College, or a technical division in existing Colleges, in all the large towns in the United Kingdom.

Though the claims of technical education are gradually being recognised by the best men in the profession, still there exists a good deal of distrust of the so-called *theoretical* man, among those whose training has been almost entirely practical, and I am sure that unless a certain amount of pressure be employed, the progress made in technical education will be small, and I also think it is pretty evident to all, that to induce parents to spend their own money and their son's time in obtaining a proper technical training, and also to induce the young men themselves to work at some definite course of study, some more urgent motive is required than intellectual advantage.

If this motive is not supplied in the way I have indicated—or in some similar way—by the Institution, then it is sure to be supplied in quite a different fashion in a comparatively short time, when Englishmen will find themselves thoroughly beaten in every branch of manufacture, by those nations which have paid special attention to the training of their engineers and manufacturers. As Dr. Lyon Playfair has said: "It is for the United Kingdom "to determine whether she desires her history to be that "of a country which was raised to the highest place among "States, by the genius of a few mighty men, though she "lost that position by a blind reliance on the practical

"empiricism of her people; or whether her future history "is to be that of an enlightened nation, which, seeing that "a general diffusion of science and art is giving to other "countries advantages in industrial competition, added "this intellectual power to the practical aptitude of her "population. It is a truth incapable of being gainsaid "that science must be joined to practice in the advancing "competition of the world, in order that a nation may "retain its strength and energy of manhood, for States, "like individuals, fall into decrepitude and decay."

Encouragement ought to be given.

In addition to the pressure I have mentioned, it would, however, be advisable to give a little encouragement to those among the artizan classes who display ability, by the institution of scholarships and bursaries. These should not be more in value than £50 a year, nor should the number be very large for any one College, the object being not to defray all the expenses of the student's education, but rather to assist those who are able and willing to help themselves. It would be a national calamity if we promoted technical education at the expense of that manliness which is the foundation of all true greatness.

Cost of proposals, and sources from which the money ought to be obtained.

Let us now consider how much it would cost to carry out the proposals I have made. As the general scientific subjects would, for the most part, be taught by Professors in the existing Colleges, we require only to consider the expenses of the special technical subjects required by engineers. For these subjects I have proposed three Professors and two Instructors in each College.

The Professors ought to have at least £500 a year and the fees; the Instructors should not get more than £100 a year, and the office should be tenable by the same person for only three years, and be looked upon as a stepping-stone to a Professorship, and not a permanent position, as it might be, if the salary were larger. If, in addition, £300 were allowed for class expenses, we would have a total for each College of £2,000 per annum, and

fifteen such Colleges in the United Kingdom would be sufficient to supply all that was wanted for many years to come.

From what source should this money be obtained? In my opinion it ought to come from the Imperial Exchequer.

The nation as a whole would benefit by the arrangement, and it would be unfair to tax only the localities in which the Colleges happened to be situated, as the students would come from all parts of the country, and be scattered to all parts of the world. This question of granting money for educational purposes cannot be decided by any abstract principle of political economy, as some politicians would have us believe. It is simply a matter of expediency.

Is it, or is it not of the utmost importance to the nation at large, that every opportunity should be afforded by which talent of whatever kind should be developed and rendered available for the country? I think no one will reply in the negative.

In order, however, to allow an outlet for local generosity, I think the bursaries and scholarships should be supplied by private donations, and also that a great part of the funds required for museums, laboratories, &c., should be provided from the localities in which they were situated, as, in addition to being useful to the students and professors of the College, they could be taken advantage of by the inhabitants generally, and those local endowments of Professorships which exist should be employed in encouraging original research in the laboratories.

The expenses connected with the examinations which I have proposed to be undertaken by the Institution would be considerable, but, *if need be*, I have no doubt the Members would be willing to bear them.

As there appears, however, to be a large amount of money in London, belonging to the City Companies, which is available for the purposes of technical education, I think, instead of founding a Central Technical University as has

been proposed, which would be likely to prove a failure, or if successful would really be a curse, that this money should be spent in furthering such examinations, not only for Civil and Mechanical Engineers, but for every technical profession and industry in the country.

No expensive buildings or organization is required for this purpose, but only that some of the money be handed over to the representative bodies of the various trades and professions, and the united Councils of these bodies would really be the Council of a Central University.

Since the above was written I have received a copy of Mr. George Howell's "Conflicts of Capital and Labour," in which I find the following passages :—

"One of the effects of general education will be that the "necessity for so long a term of apprenticeship will be "lessened ; the sharp and active boy who enters the work- "shop at fourteen will have acquired at eighteen what in "former times could scarcely have been obtained at the "age of twenty-one, and hence a three, four, or five years' "apprenticeship, according to the nature of the trade, will "serve the purpose equally as well as the full seven years "in the past. It is when he commences to learn the "handicraft that the real work of technical education must "begin ; the youth can only be taught the general "scientific principles which appertain to his craft, and "their application in the workshop, after he has begun to "learn his trade ; and this instruction should be continued "side by side with the experience gained from time to time "in his daily labour. Apprenticeship, in some form or "other, will still be needed, nay, is imperative in learning "a trade, as nothing can supersede this ; technical educa- "tion will assist in developing and guiding the latent "skill and defined expertness of the boy, and thereby pro- "duce a class of handicraftsmen who, in the higher "branches of art workmanship, will be second to no class "of workmen in any part of the world.

"The guilds of London, with their vast wealth and "historical associations, may well take the lead in this great "movement; the initiative on a large scale can be theirs: "much preliminary work must, however, be done in order "to prepare the working people to receive this instruction, "and to stimulate them to seek this valuable and indis- "pensable auxiliary, help and training; the subject is "surrounded with difficulties; the opposition of some, and "the apathy of others, will be obstacles to be overcome, "but these are not insurmountable; in order, however, to "make any scheme effective and permanent it must have "Government aid, and be under executive control, for by "no other means shall we be able to reach the furthermost "corners of these islands, and bring the blessings of such "a beneficent enterprise home to every door."

The remarks in the last sentence agree with what I have recommended above, namely, that the Government should aid in the teaching, and that the Institution of Civil Engineers should control the practical examinations.

Summary of proposals.

My proposals then are shortly these:—

1st—That the technical education of Civil and Mechanical Engineers be undertaken by existing colleges, and by new colleges of the same type, and not by special technical institutions.

2nd—That on the completion of the college course, those students who attain the required standard should receive a diploma for their scientific and technical knowledge.

3rd—That all the students should serve a pupilage or apprenticeship of at least four and a half years.

4th—That on the completion of their apprenticeship they should be examined in the application of their scientific and technical knowledge to practical problems, by a committee appointed by the Institution of Civil Engineers.

5th—That no Members be appointed to the Institution of Civil Engineers who have not gone through the course indicated—except in such special cases as are mentioned above.

6th—That a higher course of theoretical training and investigation be arranged for those who are able and willing to undertake it, after the completion of the above course.

In discussing this paper, I wish the Members of the Institution to consider these six points as the essential parts of my proposals, and any details I have given may be looked upon merely as suggestions which might be useful in attempting to carry these proposals into practice.

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